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Science Examination, May 1868.  
Reports.

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Reports sent in by some of the Professional  
Examiners of the Science and Art Department on the Examination in Science, held  
in May 1868.

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*Published for the Information of Teachers and Pupils.*

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SUBJECTS I., II., III. — PRACTICAL PLANE AND SOLID  
GEOMETRY, MACHINE DRAWING, AND BUILDING  
CONSTRUCTION.

One cause of the inefficiency in the instruction in these subjects is the idea most persons have, whose knowledge of geometry is solely derived from "Euclid's Elements," of the limited extension of lines and surfaces, especially the straight line and plane. Accustomed in *plane* geometry to the representation of polygons bounded by lines, they seldom recognise the fact that these figures are only parts of planes extending without limit in all directions, and they have the same mistaken notion of the lines bounding these figures. The consequence is that when they wish to represent a plane figure by means of its projections on rectangular co-ordinate planes, or in common terms by means of its *plan* and *elevations*, they endeavour to effect their purpose by awkward circuitous constructions confined to the figure itself, when if they were conversant with the modes of determining by practical *solid* geometry an indefinite plane anyhow situated in space, and lines lying in that plane, or parallel or perpendicular or in any direction inclined to it, they could draw the projections of any combination of such plane figures, forming the boundary surface of a geometrical solid with the shortest and least confused constructions.

But such limited knowledge as this would be of little service in the application of solid geometry to the graphical representations of works of architecture or engineering. To effect these a knowledge of the geometry of curved surfaces, especially those of *revolution*, with the properties of their *tangent planes*, their mutual *intersections* and *developments* is absolutely necessary; and of this higher geometry the "Elements of Euclid," as used in our schools, is entirely



destitute. To master the constructions for drawing the graphical representations alluded to, it is necessary to be early conversant with the idea of all surfaces, including the plane, as being *generated* by the motion of a line, this motion being determined by some condition. In many elementary works the sphere, cone, and cylinder are defined as being generated by the revolution of a semicircle, a right-angled triangle and a rectangle about one of their lines considered as a fixed axis. This conception must be extended and generalized to include other surfaces, and all admit of more than one mode of generation. All graphical operations regarding surfaces, their contacts, and intersections are founded on the representation of these surfaces by means of that of their *generatrices* in consecutive positions.

It must not be supposed that much, or even any knowledge of analytical geometry, although it would aid the draughtsman, is absolutely necessary for the acquirement of this knowledge of drawing. The 11th book of Euclid, carried further by the learner's powers of making deductions, together with numerous and varied exercises, will suffice.

Another error in the instruction in Subjects II. and III. must be pointed out, as immediately connected with the foregoing remarks. In the delineation of all the works of man the principle of *symmetry* which characterises all such works should be constantly borne in mind. Every building or constituent part of a building consists of the repetition of the same forms on each side of a central *axis*. A line on the drawing to represent such axis should invariably be first determined, and the same observation applies to the various parts of a machine, the radii of a wheel, the frame of an engine or machine; the axis of a rod, even the separate teeth or cogs of a wheel, are all symmetrical on two sides of a central line; and no accuracy in drawing can be hoped for unless these central axes of symmetry be first drawn. This foundation of all correct drawing is but too often neglected by the pupils, and accordingly their machinery would not work nor their structure stand as they represent them. A little knowledge and trouble on the part of the teacher in pointing out and explaining these simple principles would lay the foundation of better work and greater progress than has hitherto characterised the papers in these subjects.

In Subject III. it is difficult to apportion the causes of failure between indifferent "drawing" and want of knowledge of "construction." Generally these concur; the candidate who has not learned to draw tolerably can have little or no knowledge of building; but this is not neces-



sarily the case, and there are many instances of excellent drawing which do not indicate sound knowledge, as well as of good practical knowledge with no power of drawing.

The pupils in the various schools, &c., have apparently only been set to copy diagrams without having the principles of building construction explained to them. In timber framing of roofs, floors, and partitions they do not comprehend the necessity for a difference in the "scantling" required to sustain a cross strain from that which has only to resist a thrust; and in the framing their mortices, &c., would cut the timber in two.

The candidates have selected questions with high numerical credit in the hopes of obtaining a higher class without stopping to consider whether they understood what they were about to draw. This is particularly exemplified in the subject of wrought iron lattice framing. A notice was given in the paper of the necessity of placing the rivets correctly, as shown in the sketch; but in most instances the candidate has entirely disregarded it and treated his rivets as if they were nails in wood work.

As on previous occasions the candidates have shown a reckless disregard of the "General Instructions" placed on the paper, as well as of the "conditions" of the several questions. Probably from these causes they have forfeited 20 per cent. of the credits they might otherwise have gained.

Lastly, I must state that in this subject, as well as in Subjects I. and II., the relation of plan, elevation, or co-ordinate projection is not explained properly to the pupils. They often place the plan and elevation in different parts of their paper and often to different scales, and will select the plan of one subject, the elevation of another, and the section of a third in the most arbitrary and absurd manner, and do not appear to be aware of the futility of such proceeding.

(Signed) THOMAS BRADLEY.

### SUBJECT III.—NAVAL ARCHITECTURE.

SIR,

WITH reference to your letter of the 26th inst. (S), requesting me to furnish you with any remarks I may have to make on the late Science Examination, such as would be useful to communicate to teachers for their future guidance, I beg leave to remark that in most of the worked papers



in naval architecture the sketches which were required to be drawn to scale were very roughly executed instead of being neatly and correctly made; and as regards that branch of the subject termed laying off, the answers should have been elucidated by diagrams, so as to render them more complete and intelligible, whereas some of the candidates attempted these questions without diagrams.

The teachers, therefore, would do well to enjoin upon their pupils neatness and accuracy in drawing, and a more extensive use of diagrams, observing, however, that it is not necessary that illustrative diagrams should be drawn to scale, as a hand sketch in most cases will be sufficient.

I have, &c.

The Secretary,  
Science and Art Department.

(Signed) W. B. BASKCOMB.

#### SUBJECTS IV. and VI.—ELEMENTARY MATHEMATICS, AND THEORETICAL MECHANICS.

##### MY LORDS,

THE direction received from your lordships to prepare a report on the result of examination in 1868 in elementary mathematics and theoretical mechanics only came to me after the papers had been read, marked, and returned to the office, so I write from remembrance of the general character of these papers and not from having them now before me.

1. My first remark is one which might be expected. The candidates often seem hardly aware of their own power or want of power; they do not know whether they ought to take the easy paper or the more difficult paper. Some, after attempting the latter, have erased their answers, taken the easy paper, and done very fairly in it. This indicates defective teaching. The science teacher should have made himself well acquainted with the programme, and should have told the candidate exactly what to do beforehand; and the skill and judgment of the teacher are defective if he has not succeeded in making his pupil have confidence in his directions.

2. Young men are sometimes sent into the examination who ought not to be allowed to try. Their knowledge is so small that they merely give trouble with no corresponding



advantage to themselves. It ought to elicit from the Department a rebuke to a teacher who sends in many ill-prepared students. The teacher must know well whether his pupils are likely to do themselves credit in the examination; he should hold a preliminary examination of his own of all his class like that which is to be expected, and refuse to let those candidates present themselves who are merely going in with a tentative or fishing expectation of finding some easy questions or to get accustomed to examinations of this kind. The Government gives encouragement to real knowledge, and wishes to excite a desire for scientific acquirement. I have sometimes thought it would be well if such preliminary trials were established before the local boards, that those who are incompetent may be weeded out, and not give your examiners the trouble of reading over papers which reflect no credit on the candidates or their teachers.

These remarks apply generally to both subjects entrusted to me.

3. I pass on to more technical details. Some candidates omit to give the actual work of their solutions or answers to the questions. Very little if any credit can be given to those who only give the final answer without showing the steps by which they have arrived at it, because the examiner cannot feel sure that the result is of their own production.

The work ought to be given always in connexion with the answer and not in a different part of the paper. The separation of the actual work from the answer gives a great deal of needless trouble to the examiner.

The numerical calculations should be clearly written and well arranged in order to secure the full marks.

4. Some candidates do not seem to understand that when a proposition is stated it is to be *proved*, not assumed. No credit can be given for answers which are merely a wordy and lengthened paraphrase of the scientific enunciation; very little for mere numerical illustrations; *e.g.*, Q. 23, Elementary Mathematics, begins, "Show how to find the area of a quadrilateral, &c., &c." Many candidates have merely given the rule without proving it. It should be remembered that in such questions "show," means "prove" "the rule to be true."

This illustration might be given in many other cases, as, when a question begins "Find," and so on.

Technical terms are also misunderstood by those who imagine that "proposition" always means a proposition of



Euclid or plane geometry (Q. 12, Elementary Mathematics). Any enunciation may be called a "proposition."

5. No candidate ought to pass in the lowest class in elementary mathematics who has not some elementary knowledge of trigonometry. (See the syllabus.) Many candidates seem to have scarcely made any progress in this subject.

6. In theoretical mechanics candidates should not pass unless they have some elementary knowledge of dynamics.

7. In the more difficult paper in mechanics the candidates should remember that their answers should be full, and that it is expected they will state very accurately the principles they assume, with strict attention to scientific phraseology, or else the examiner must assume an imperfect acquaintance with the subject.

The questions selected should be those which show that they can cover the whole subject; and those who obtain the highest marks are invariably those who show accuracy and completeness.

Q. 20 was a test of this knowledge. Many who attempted it did not seem to know the difference between rolling and sliding motion.

In Q. 23 scarcely any knew of the law of resistance, or assigned any reason for it of a mathematical kind, nor did they give any of the familiar illustrations which are so admirably explained in "Moseley's Mechanics applied to the Arts," which is an invaluable book for the purpose of these examinations, because it makes the student familiar with the importance of mechanical science in practical questions and shows how to apply our knowledge.

I think that attention to the few points here mentioned will secure a more satisfactory result both to candidates and teachers.

On a future occasion, if your Lordships should entrust these papers to me, I shall notice many details in the course of looking over the papers which may be made the subject of comment for the improvement of the work. I may say in conclusion that the examination of 1868 shows very considerable advance in the better candidates, and that I think many have shown that they have been well taught even when their marks have not been large. Inaccuracy and clumsiness of expression often reduce the credit of an answer when it is easy to see that main principles have been grasped. This is necessary, we must visit such in-



accuracies with loss of marks in order to secure to those who are accurate their due superiority in the class.

I have, &c.

(Signed) B. M. COWIE,  
Examiner in Elementary Mathematics  
and Theoretical Mechanics.

The Lords of the  
Committee of Council on Education,  
Science and Art Department.

SUBJECTS V., XX., XXI., and XXII.—HIGHER MATHEMATICS,  
NAVIGATION, NAUTICAL ASTRONOMY, AND STEAM.

1. With respect to higher mathematics I have few remarks to offer: the answers on the whole were good, but the number of candidates was small. It would be desirable to introduce plane co-ordinate geometry, including the principal properties of the ellipse, parabola, and hyperbola into this course.

2. The number of candidates in navigation is greater than usual, and some of the papers are better than I have had before. A large proportion of the candidates have attempted the more difficult paper. In some instances the answers in the simple or easy paper betray a very insufficient knowledge, and lead to the suspicion that candidates present themselves who have bestowed very little time on the subject. The chief failure is in the definitions and elementary propositions.

3. In nautical astronomy a much larger proportion than usual of the candidates show considerable knowledge of the theory. In one batch of papers, apparently from the same schools, this theoretical knowledge has been cultivated too much at the expense of accuracy in working out the numerical examples, and in taking out the elements from the tables and the Nautical Almanac. In this subject too, even where some of the theoretical problems have been correctly solved, there is a confusion and indistinctness in the statement of definitions.

4. The papers on steam on the whole are not satisfactory; few of the candidates enter sufficiently into detail. There are some exceptions of very fairly worked answers.

I have, &c.

(Signed) J. WOOLLEY.

### SUBJECT VII.—APPLIED MECHANICS.

The general result of last examination in the subject of Applied Mechanics can barely be considered satisfactory ; from remarks made in several of the papers it would appear that many of the students were scarcely prepared for the questions that were put to them, but this will no doubt be remedied to some extent at next examination.

The next set of questions will be of a similar character, and will have reference only to general mechanical applications such as all students of subjects connected with machinery, engineering, or building operations may be supposed to have some knowledge of.

The Syllabus given in the Science Directory contains the leading divisions of the subject, and the questions will embrace more especially the mechanism of engineers' workshops, the prime movers of mills and factories, pumping arrangements, and machinery in connexion with fire, air, and water. The students should also become acquainted with the strength of materials, such as cast iron, wrought iron, steel, chains, &c., likewise with the subject of friction as depending on pressure and materials.

I have, &c.

(Signed) JOHN ANDERSON.

### SUBJECTS X. and XI.—INORGANIC AND ORGANIC CHEMISTRY.

SIR,

THE examinations in inorganic and organic chemistry, the numerical results of which you have already received, are on the whole very satisfactory ; 964 candidates presented themselves for examination in inorganic chemistry, 481 having selected the more difficult paper. In the subject of organic chemistry 123 papers were sent in, 64 of them containing answers to the second or more difficult series of questions.

The order least generally complied with is that requiring the candidate to give such numerical details as will show the mode of calculation. In many cases the result only of the calculations are given in the answer, and it was only by searching through the papers to find the candidate's private notes (which were evidently not intended to be



seen by the examiner, and which were frequently crossed out so as to be nearly illegible) that the method by which the result was obtained could be found. Teachers ought to impress upon their pupils the necessity for strictly complying with this part of the instructions, as also the desirability of working with decimals instead of vulgar fractions. Altogether more care should be taken with the arithmetical portion of the answers, as very erroneous results have in many cases been given through omitting a cypher in the quotient of a long division sum and putting decimal points in wrong places.

As a general rule the writing has been legible, but the spelling and grammar were, in not a few cases, very bad.

The new notation has been used in a very large majority of cases, thus encouraging the hope of the early realization of a substantial uniformity amongst teachers in this important matter.

The answers to questions No. 15 and 23 (inorganic series) show that the modern doctrines of atomicity or equivalence have already received a very extensive adoption amongst chemical teachers.

Question 17, "What meaning do you attach to the terms "acid, base, and salt?" has elicited the great desirability of using much sharper definitions of these important terms than those generally employed by teachers. Scarcely one candidate has given definitions of these great classes of chemical compounds, which are not open to some objection, and most have contented themselves by saying that an acid is that which combines with a base; a base is that which combines with an acid; and a salt is a combination of the two.

The answers to the questions involving some knowledge of analytical chemistry show that very few of the candidates have had the advantage of laboratory manipulation and they have consequently fallen helplessly into the error (unfortunately fostered by some of our text books), of giving special tests for individual elements regardless of the admixture, and consequent interference, of other substances. It is but rarely that the candidate displays any knowledge of the necessity for separation in the operations of qualitative analysis.

It might be anticipated that the subject of organic chemistry would only be attempted by more advanced pupils, and this in fact appears generally to have been the case; consequently the answers to the organic paper

display a more uniform proficiency than those returned to the inorganic paper. Some of the papers worked in organic chemistry are extremely good and indicate a considerable amount of careful and systematic reading.

I have, &c.

(Signed) E. FRANKLAND.

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## SUBJECT XII.—GEOLOGY.

SIR,

HAD I received notice that a report was desired on the science examination in geology before I went over the papers, I could have taken such notes as would have enabled me to give a detailed report on the style of teaching that these papers indicate. So much time, however, has elapsed since I gave my award that I cannot now charge my memory with those observations that occurred to me while reading the papers. On the whole I incline to think that the majority of the pupils have been very fairly taught. The defects of many of the papers are not entirely due to the teacher or teachers, but to the exceedingly imperfect preliminary education of the persons examined. Some can barely write, and even of some who can write decently the grammar and spelling is exceedingly defective. A considerable number do not know the meaning of the words *genus* and *species* which are of constant occurrence in manuals of geology. Very few can draw illustrative diagrams in a creditable manner, and I doubt if the pupils have always good examples of this style of drawing set before them by their teachers with the help of a black board and chalk.

There is a general tendency also in many of the teachers to attribute all the irregular features of ground and especially of mountain chains to earthquakes and volcanic eruptions, and also to describe various old phenomena as "*gigantic*" where there was nothing specially large about them.

In most cases, however, as a whole, the style of teaching is deserving of praise, and as far as I remember it has improved since these examinations began.

I am, &c.

(Signed) ANDREW C. RAMSAY.

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# SUBJECTS XIV. and XV.—ANIMAL PHYSIOLOGY AND ZOOLOGY.

SIR,

THE papers in the late examination in physiology exhibit a very decided advance upon those sent in three or four years ago, and upon the whole they are better in quality, as well as far more numerous, than those of last year.

There is still, however, considerable room for improvement, chiefly in the following respects :—

1. Many of the candidates are taught physiology before they have learned to spell or write English.

Now it is perfectly true that a knowledge of natural facts and laws is of more value than orthography, and that a real conception of the phenomena of the circulation (*e.g.*) may be shown by persons who spell "auricle," *oricle*; "ventricle," *ventrical*; "heart," *hart*; and who write plural nouns with singular verbs. Nor do I think it part of my duty as examiner in science to take particular note of such defects. But I confess that I think that their existence is much to be regretted, and indicates a very faulty condition of primary education.

2. As will occur in all examinations, many of the candidates in physiology exhibit obvious signs of having undergone the process of grinding instead of that of instruction.

It often happens that identical phrases run through all or the majority of a series of papers, the consecutive numbers of which show that they belong to one school. A man puts what he really knows into his own language, and coincidences of this kind afford strong presumptive evidence that the candidates have been drilled in groups without much care being taken to ensure the apprehension on the part of each individual of that which he has learned to repeat.

3. The defect last mentioned arises from slovenly teaching. There are a great many papers, however, which exhibit the results of very careful and conscientious teaching, the only fault of which is that it has obviously been all book work. Now no branch of physical science can be adequately comprehended by the study of books alone; and as a discipline much of the value of science depends upon its bringing students into direct contact with facts.

I am quite aware of the practical difficulties in the way of putting even the leading parts of elementary physiology and physiological anatomy before school boys and school girls; but they are to be overcome by a little patience and ingenuity.



The circulation of the blood and the chief properties of living nervous and muscular tissue may be demonstrated with great ease upon one of the commonest of animals, the frog; and a butcher's shop will supply the means for demonstrating all that is essential in the elements of the physiological anatomy of man.

4. The only other point which it seems necessary for me to notice with regard to the physiological papers is the want of accurate acquaintance with very important but very elementary matters which is frequently exhibited by candidates who display a fair acquaintance with more difficult topics. Not unfrequently I am compelled to reject a candidate who obtains half marks or more because he blunders over the course of the blood through the heart, or declares that the gastric juice is alkaline, or that the diaphragm is composed of cartilage, or that this organ is passive in the respiratory movements.

The papers on zoology are far inferior to those in physiology. This inferiority arises from several causes, amongst the chief of which must be noted the want of good text books, of specimens for study, and of a preliminary acquaintance with the outlines of human anatomy and physiology.

In my opinion it is much to be regretted that any attempt should be made to teach zoology to persons who have not already passed in physiology, and, at lowest, in the second class.

I am, &c.

(Signed) T. H. HUXLEY.

#### SUBJECT XXIII.—PHYSICAL GEOGRAPHY.

SIR,

IN forwarding the results of the examination in Physical Geography, I beg to submit the following remarks.

I find it difficult to make any general report that shall apply to all teachers. As a rule, there is a tendency to write too much, and even to give essays, on parts of the subject not referred to in the questions. Perhaps, if teachers would give their pupils occasional examinations as far as possible in the style of the May examinations, the result might be satisfactory both to the pupils and the professional examiner.



I have been obliged to reject nearly one-third of the candidates. This would hardly happen if the teacher was in some measure acquainted with the pupil's capacity by actual experiment. One or two examinations in the class room would remove nervousness and give confidence.

I desire to point out also the marked difference observable in different groups of papers, some indicating very imperfect knowledge on the part of the teacher, and others giving accurate replies, but always in the same words, thus proving that the teaching has been confined to mere cram. It is very desirable that the answers given to questions should be as far as possible in the words of the pupil, not a quotation from a book or from the teacher's lessons. It would not be difficult to point out special cases where the teaching has been exceedingly bad.

It cannot be too strongly impressed on teachers that clear definite answers, strictly confined to the questions set and not discursive, must always be accepted as the best and most valuable, and will obtain the highest number of marks.

I am able to state that the answers given by those who have obtained a first or second class show a decided advance over last year.

In the first class this is especially remarkable, and the number of really good papers sent in is greatly increased.

I have, &c.

(Signed) D. T. ANSTED.

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